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## COATING IN MULTIPLE INJECTION MOLDING PART CAVITIES

## 5 BACKGROUND OF THE INVENTION

[0001] The present invention relates to coating in multiple injection molding part cavities and controlling the flow of an in-mold coating (IMC) composition that is injected into multiple injection molding part cavities, more particularly to a method of (1) injection molding multiple articles in multiple injection molding part  
10 cavities and coating the multiple articles with an IMC composition, (2) using only a single injector to coat the multiple molded articles and/or (3) controlling the flow of the injected IMC composition on the multiple molded articles such that the multiple articles are only coated on desired surfaces or portions thereof. The present invention finds particular application as an apparatus and method for injection  
15 molding two articles within two-part cavities defined by mold halves of a single injection molding machine, coating the two articles with an IMC composition using a single IMC composition injector and controlling the flow of the injected IMC composition on the two articles.

[0002] Molded thermoplastic and thermoset articles, such as those made  
20 from polyolefins, polycarbonates, polyesters, polystyrenes and polyurethanes, are utilized in numerous applications including those for automotive, marine, recreation, construction, office products, and outdoor equipment industries. Often, application of a surface coating to a molded thermoplastic or thermoset article is desirable. For example, molded articles may be used as one part in multi-part  
25 assemblies; to match the finish of the other parts in such assemblies, the molded articles may require application of a surface coating that has the same finish properties as the other parts. Coatings may also be used to improve surface properties of the molded article such as uniformity of appearance, gloss, scratch resistance, chemical resistance, weatherability, and the like. Also, surface  
30 coatings may be used to facilitate adhesion between the molded article and a separate finish coat to be later applied thereto.

[0003] Numerous techniques to apply surface coatings to molded plastic articles have been developed. Many of these involve applying a surface coating to plastic articles after they are removed from their molds. These techniques are

often multi-step processes involving surface preparation followed by spray-coating the prepared surface with paint or other finishes. In contrast, IMC provides a means of applying a surface coating to a molded article prior to its ejection from the mold.

5 [0004]       Molds used with thermoplastics usually are of a "clam shell" design having mated halves that meet at a parting line. One of the mated halves typically remains stationary whereas the other half typically moves between a closed position and an open, retracted position. To form a molded article, the movable half is moved to its closed position and held closed under a clamping force  
10 thereby forming a contained molding cavity. Molten material is injected into the molding cavity. The molded article is formed by thoroughly filling the cavity with the molten material and allowing the material to sufficiently cool and solidify. During the entire molding process, the movable mold half is maintained in its closed position. After molding, the mold halves can be opened and a finished,  
15 molded article ejected therefrom.

[0005]       Owing to differences in mold design and molding conditions, processes where the mold is cracked or parted prior to injection of a coating composition generally are not used for the IMC of injection molded thermoplastics. When molding thermoplastics, it is generally necessary to maintain pressure on  
20 the movable mold half to keep the cavity closed and prevent material from escaping along the parting line. Further, maintaining pressure on the thermoplastic material during molding, which also requires keeping the cavity closed, often is necessary to assist in providing a more uniform crystalline or molecular structure in the molded article. Without such packing (i.e., pressure  
25 maintenance), physical properties of the molded thermoplastic article tend to be impaired.

[0006]       Because injection molding does not permit the mold to be parted or cracked prior to injection of the IMC composition into the mold cavity, the IMC composition must be injected under sufficient pressure to compress the article in  
30 all areas that are to be coated. The compressibility of the molded article dictates how and where the IMC composition covers it. The process of IMC an injection molded article with a liquid IMC composition is described in, for example, U.S.

Patent No. 6,617,033 and U.S. Patent Publication Nos. 2002/0039656 A1 and 2003/0082344 A1.

[0007] A method and apparatus used to physically inject liquid IMC composition into the molding cavity of an injection molding machine during the molding process, also referred to herein as a dispense-and-control method and apparatus, is described in commonly owned, copending International Application No. PCT/US03/33186 (WO \_\_\_\_\_) the teachings of which relating to that method and apparatus are incorporated herein by reference. The dispense and control apparatus provides a delivery system for injecting an IMC composition into the cavity of a pair of mold halves on an injection molding machine and a means for controlling the delivery system.

[0008] As the IMC composition is injected into the mold cavity and onto the molded article, the flow of the IMC composition can be controlled such that only desired surfaces or portions of surfaces of the article are coated and that those surfaces are optimally coated. Further, the flow of the IMC composition can be controlled so as to limit it from escaping through the parting line or entering the area near the resin injection orifice.

[0009] For example, one method for selectively controlling flow of IMC composition flow is described in US 2003/0082344 A expressly incorporated herein by reference, which teaches methods for controlling the flow and thickness of an IMC composition as it is injected into a mold cavity and onto a molded article. Generally, by controlling the thickness or depth of various areas or sections of the molded article, desired areas of the article can be preferentially coated. Specifically, when a molded article is provided with an area of increased relative thickness at or near the location of the IMC composition injection, flow of the IMC composition is promoted. When the molded article is provided with a runner section or preferred flow channel, IMC composition flow over the surface of the molded article is promoted. Additionally, when the molded article is provided with a containment flange, the flange acts as a barrier and prevents the IMC composition from leaking or seeping off a desired surface and/or out of the mold cavity.

[0010] Another method for selectively controlling in-mold coating flow is described in US 2003/0077426 A, expressly incorporated herein by reference,

which teaches the use of "flow zones" near the IMC composition injection inlet area to promote the flow of IMC composition from the injection inlet area. Still another method for selectively controlling IMC composition flow is described in US 2003/0099809 A, expressly incorporated herein by reference, which discloses a

5 containment flange functioning like the containment flange described in the US 2003/0077426 A publication but with the added feature of being configured to be removable from the coated thermoplastic article. The removable flange is able to be easily removed. Still yet another method for selectively controlling in-mold coating flow is described in US 2003/0077425 A publication, expressly

10 incorporated herein by reference, which discloses the use of a mold structure formed as part of the molded article that provides a barrier preventing IMC composition flow into the resin injector orifice, gate pin assembly, or the like.

[0011] In some injection molding applications, multiple articles may be simultaneously injection molded on a single injection molding machine. More

15 particularly, a single injection molding machine can include a set of mold halves that define more than one part cavity. When the mold halves define multiple part cavities, multiple articles can be molded therein, typically one article per part cavity. In these types of applications, it may be desirable to in-mold coat the multiple molded articles for the reasons discussed above. Accordingly, there is a

20 need for an injection molding and IMC arrangement that allows articles molded in multiple part cavities of a set of mold halves to be in-mold coated. It may be further desirable to coat the multiple molded articles using a single IMC composition injector. Whether coating with a single IMC composition injector or with multiple injectors, there is also a need for controlling the flow of the injected

25 IMC composition on the multiple injection molded articles such that they are coated only on desired surfaces or portions of surfaces.

#### SUMMARY OF THE INVENTION

[0012] In one aspect, the present invention provides a molding apparatus

30 that includes a mold defining a plurality of mold cavities, at least one first composition injector fluidly connected to the plurality of mold cavities for injection molding articles therein, and at least one second composition injector fluidly

connected to the plurality of mold cavities for in-mold coating molded articles in the plurality of mold cavities.

[0013] In another aspect, the present invention provides a molding apparatus that includes a mold defining a plurality of mold cavities, a means for injection molding articles in the plurality of mold cavities, and a means for in-mold coating the molded articles in the plurality of mold cavities.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The drawings are only for purposes of illustrating preferred embodiments and are not to be construed as limiting the invention.

[0015] Fig. 1 is a side view of one embodiment of a molding apparatus having a plurality of molding part cavities.

[0016] Fig. 2 is a schematic plan view of a mold including a movable mold half in a closed position and a stationary mold half showing (in hidden lines) the plurality of part cavities, a runner section, a sprue section and a second injector passageway.

[0017] Fig. 3 is a schematic cross-sectional view taken along the line 3-3 of Fig. 2 showing the runner section fluidly connected to the part cavities.

[0018] Fig. 4 is a perspective view of an IMC dispense and control apparatus adapted to be connected to the molding apparatus of Fig. 1.

[0019] Fig. 5 is an enlarged partial schematic plan view of the mold halves of Fig. 2.

#### DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0020] Referring now to the drawings wherein the showings are for purposes of illustrating one or more preferred embodiments of the invention only and not for purposes of limiting the same, Fig. 1 shows a molding apparatus or injection molding machine 10 including a first mold half 12 and a second mold half 14. First mold half 12 preferably remains in a stationary or fixed position relative to second movable mold half 14. In Fig. 1, movable mold half 14 is shown in an open position, although it is movable to a closed position wherein first and second mold halves 12,14 mate with one another to form a plurality of contained mold cavities 16 therebetween. More specifically, mold halves 12,14 mate along

container to metering cylinder 74. A valve is provided on the fluid line for controlling communication therethrough. Transfer pump 76 is adapted to selectively pump IMC composition of the coating container to metering cylinder 74 when the fluid line valve is in an open position.

5 [0031] Using conventional fluid communication lines, metering cylinder 74 is fluidly connectable to second injector 32 of molding apparatus 10. A hydraulic means such as a hydraulically driven piston 102 is provided for selectively evacuating IMC composition held in metering cylinder 74 therefrom, as is described in more detail below. The evacuated in-mold coating composition is  
10 directed by and through fluid communication lines to second injector 32. Control apparatus 70 includes appropriate connections (not shown) for connecting it to a conventional electric power source and a conventional compressed air source. Specifically, control apparatus 70 includes an electric box 78 capable of being connected to a conventional 460 volt AC or DC power outlet. Electric box 78  
15 includes a plurality of controls 80 and a touch pad controller 82 thereon for controlling the dispensing of the IMC composition from apparatus 70 to second injector 32 and for controlling second injector valve 66. The electric power source provides power for the electronics, electronic controls and the hydraulic pump of apparatus 70. The compressed air source provides power for air-driven transfer  
20 pump 76.

[0032] To make a coated article, with reference to Fig. 1, a thermoplastic first composition is placed in hopper 48 of the molding apparatus 10. Any suitable thermoplastic first composition that can be injection molded is suitable for use with or in the present invention. Examples of thermoplastic materials include, but are  
25 not limited to, polyethylene terephthalate (PET), nylon, acrylonitrile-butadiene-styrene (ABS), polystyrene, polycarbonate, acrylic, acetal, polyolefins such as polyethylene and polyethylene, polypropylene, and polyvinyl chloride (PVC). The foregoing list is not meant to be exhaustive but only illustrative of various useful thermoplastic materials.

30 [0033] Prior to injecting the first composition mold halves 12,14 are closed by clamp mechanism 24 to create contained molding part cavities 34,36. In the closed position, clamping mechanism 24 maintains a clamping pressure sufficient to maintain mold halves 12,14 in closed relation even when the first and second

compositions are injected under pressure into part cavities 34,36. Also prior to injecting first composition, first injector 30 is moved into nesting or mating relation with first mold half 12.

[0034] Through conventional means, e.g., using heated extruder barrel 52 and rotating screw 50, first injector 30 heats the first composition above its melting point and directs it toward nozzle 46 of first injector 30. If nozzle 46 is equipped with a nozzle valve, it is moved to an open position for a predetermined amount of time to allow a corresponding quantity of the first composition to pass through the sprue passageway and runner section to fill part cavities 34,36. Screw 50 provides an injection pressure or force that urges the first composition into part cavities 34,36 until the nozzle valve is returned to its closed position. In other words, part cavities 34,36 are filled and packed by the first composition. Once part cavities 34,36 are filled and packed, the molded first composition is allowed to cool thereby forming molded articles in part cavities 34,36. A portion of the first composition will remain in sprue passageway 38 and runner section 40 forming therein, respectively, a sprue and a runner.

[0035] After specified surfaces of the molded articles in part cavities 34,36 have cooled below their melt points or otherwise reached a temperature or modulus sufficient to accept or support a coating, the IMC composition can be injected into part cavities 34,36 and onto the molded articles. If the IMC composition is cured by heat, it desirably is injected before the surfaces of the molded articles have cooled so much such that curing would be inhibited. To inject the IMC composition, valve 66 is moved to an open position and the hydraulic means is actuated to evacuate a predetermined amount of the IMC composition from metering cylinder 74, through second injector 32, and into part cavities 34,36. More specifically, from second injector 32, the IMC composition is directed through nozzle 64 and onto the flat portion of the runner adjacent location 68. As described in more detail below, the IMC composition is directed along runner section 40 and into part cavities 34,36 to coat desired surfaces of the molded articles. The flat portion promotes the flow of the IMC composition into cavities 34,36.

[0036] The mold need not be opened or unclamped before the IMC composition is applied. That is, mold halves 12,14 can maintain parting line 22

and generally remain substantially fixed relative to each other while both the first and second compositions are injected into mold cavities 34,36. Thus, the substantially fixed volume of each of mold cavities 34,36 can be constant and maintained throughout the molding and coating steps. The IMC composition  
5 spreads and coats a predetermined portion or area of the molded articles. Immediately or very shortly after the IMC composition is fully injected into mold cavities 34,36, apparatus 70 allows valve 66 of second injector 32 to return to its closed position, thereby preventing further injection of IMC composition into mold cavities 34,36.

10 [0037] After the predetermined amount of IMC composition is injected into mold cavities 34,36 and covers or coats the predetermined areas of the molded articles, the coated articles can be removed. Before mold halves 12,14 are parted, the IMC composition is cured. The cure is optionally heat activated, from sources including the articles themselves or the mold halves 12,14 which are at or  
15 above the curing temperature of the IMC composition. Cure temperature can vary depending on the IMC composition utilized. If curing of the IMC composition is heat activated, the IMC composition preferably is injected before the molded article(s) have cooled to a point below where curing of the coating can be achieved easily or economically. These types of IMC compositions require a  
20 minimum temperature to activate the catalyst and/or initiator present therein to cause a cross-linking reaction to occur, thereby curing and bonding the coatings to the molded articles.

[0038] Controlling flow of the IMC composition as it passes from injector 32 to cavities 34,36 and onto the articles can be done by controlling the thickness of  
25 one or more portions of the articles as well as by controlling the thickness and profile design of runner section 40 leading to part cavities 34,36. For example, referring to Fig. 5, runner section 40 can be shaped to form a containment flange 40a on the runner to limit and thereby control flow of the IMC composition. The containment flange functions like those discussed in the first two of the selective  
30 flow control publications discussed above. Specifically, the containment flange contains the IMC composition as it flows between the walls defining runner section 40 and the runner formed therein due to its thin cross-section and relative lack of compressibility. Once the controlled flow of the IMC composition reaches cavities



34,36, the shape of the molded cavities therein can further control the flow of the IMC composition in cavities 34,36 and on the molded articles such that only desired surfaces or portions of surfaces are coated. In the illustrated embodiment, the containment flange on the runner could be formed along parting line 22 and the surfaces to be coated on each of the articles formed in part cavities 34,36 could be adjacent second mold half 14. Thus, the IMC composition can be contained and only allowed to flow on the second mold half side of parting line 22.

[0039] Although the present invention has been illustrated and described as having two mold halves defining a pair of cavities that receive an IMC composition from a single injector, other arrangements are contemplated and within the scope of the present invention. For example, the mold halves may define one or more than two part cavities. Another arrangement would employ separate IMC composition injectors and/or control and dispense apparatuses for each cavity defined in the mold halves. Yet another arrangement would employ a single injector adapted to provide IMC to part cavities located in different sets of mold halves.

[0040] Further alternative arrangements are contemplated. In one such embodiment, injector 32 can be mounted on first mold half 12 and coat a side of the runner formed in runner section 40 adjacent first mold half 12. Alternatively, with second injector 32 mounted on first mold half 12, IMC composition can be directed through mold half 12 to the sprue formed in sprue passageway 38. Various arrangements of containment flanges can be formed along sprue passageway 38 and runner section 40 to direct the IMC composition injected to part cavities 34,36. In another such embodiment, second injector 32 can be oriented to directly inject IMC compositions onto a desired surface of one of the articles formed in part cavities 34,36. The IMC composition then can be directed to coat that article and flow along runner formed in the runner section 40 to coat the article formed in the other of part cavities 34,36. In still yet another alternative embodiment, second injector 32 can be used to deliver IMC composition directly to a plurality of locations on any combination of the article formed in first cavity 34, the article formed in second cavity 36, the sprue and/or the runner. Second injector 32 would deliver the IMC composition to the plurality of locations by using passages that branch off one another.